Developing Effective Ecosystem Monitoring Strategies for Military Activities in Deserts: Yuma Proving Ground

Dirt, Shrubs, and Soil Hydrology in Desert Environments

Eric McDonald
Desert Research Institute
Earth and Ecosystem Sciences

Valerie Morrill
Yuma Proving Ground

Developing Effective Ecosystem Monitoring Strategies for Military Activities in Deserts: Preliminary Results from Yuma Proving Ground

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Legacy Program

Management of Desert Ecosystems

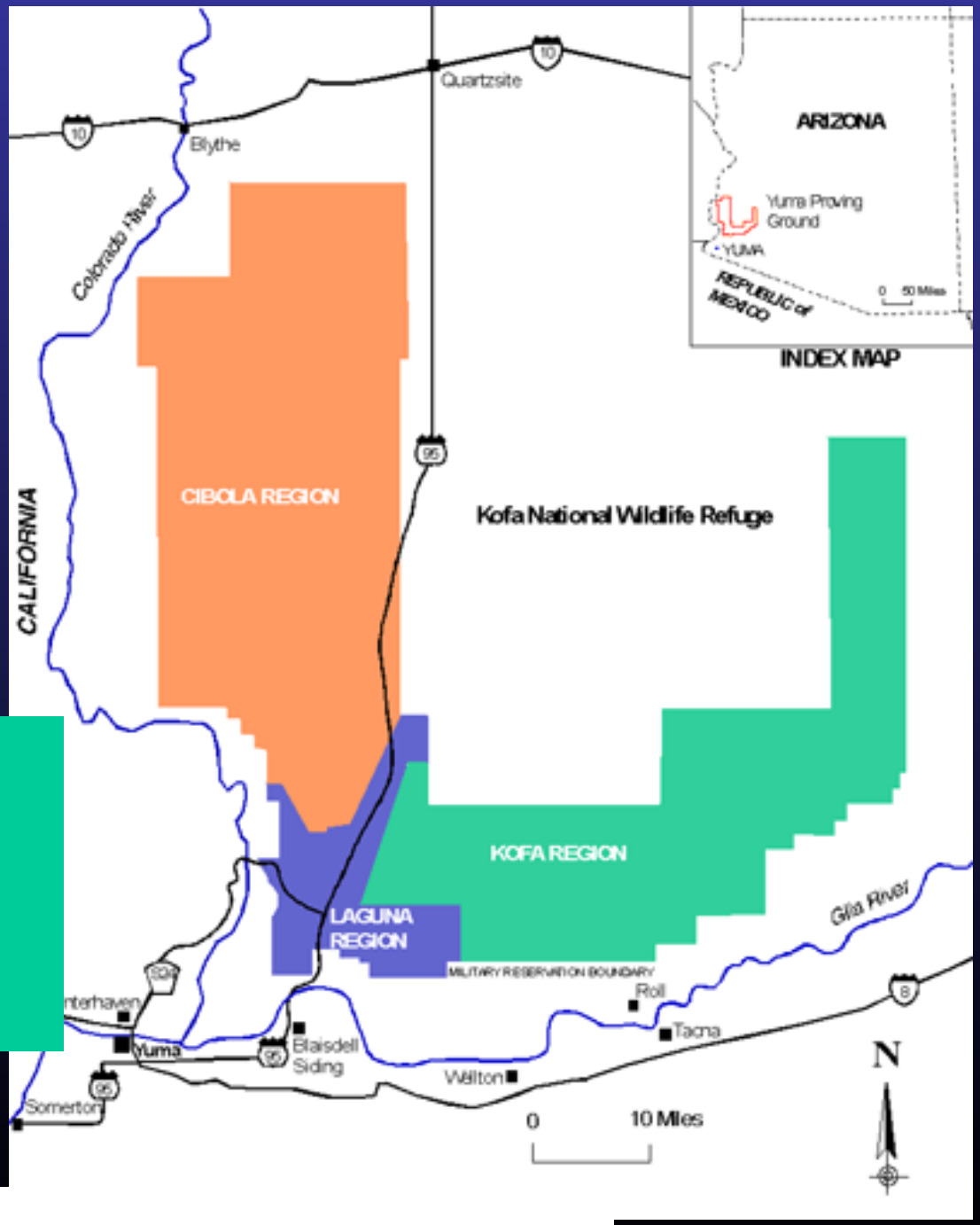
- 70% of DoD lands in dryland regions
- New weapons/tactics require additional operational space
- Increased public interest in desert lands
- Deserts susceptible to climatic change and land use impacts
- Many gaps in scientific knowledge of desert ecosystems, especially linkage among landscape, climate, and vegetation processes

Outline

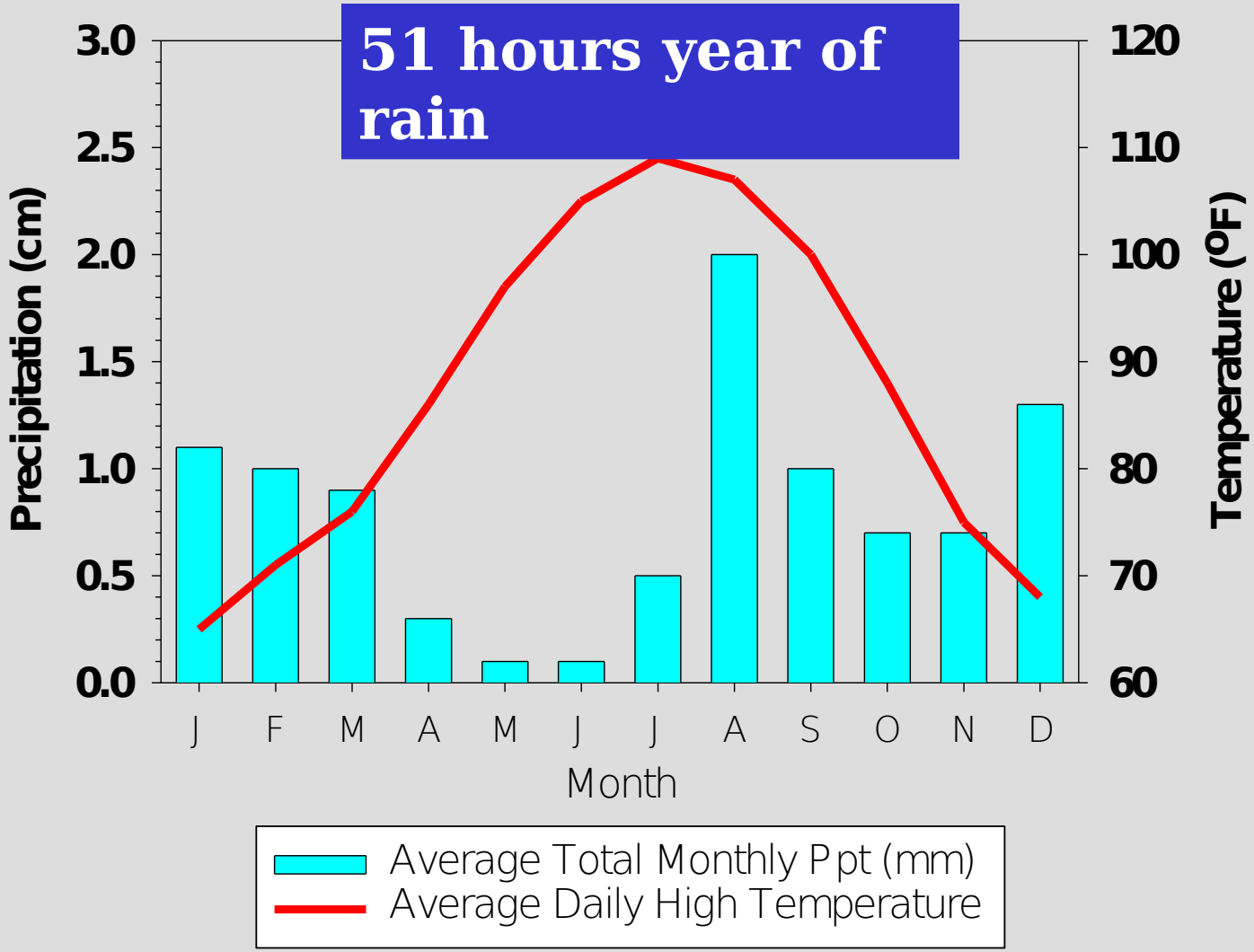
- **Physical Setting**
- **The Problem**: Develop effective ecosystem monitoring strategies.
- **Solution**: Determine linkage between water and vegetation dynamics
- **Project**: Integration of soils, landscape position, vegetation, and hydrology for ecosystem management:
- **Results**
  - **1st order channels**
  - **Plant scars**

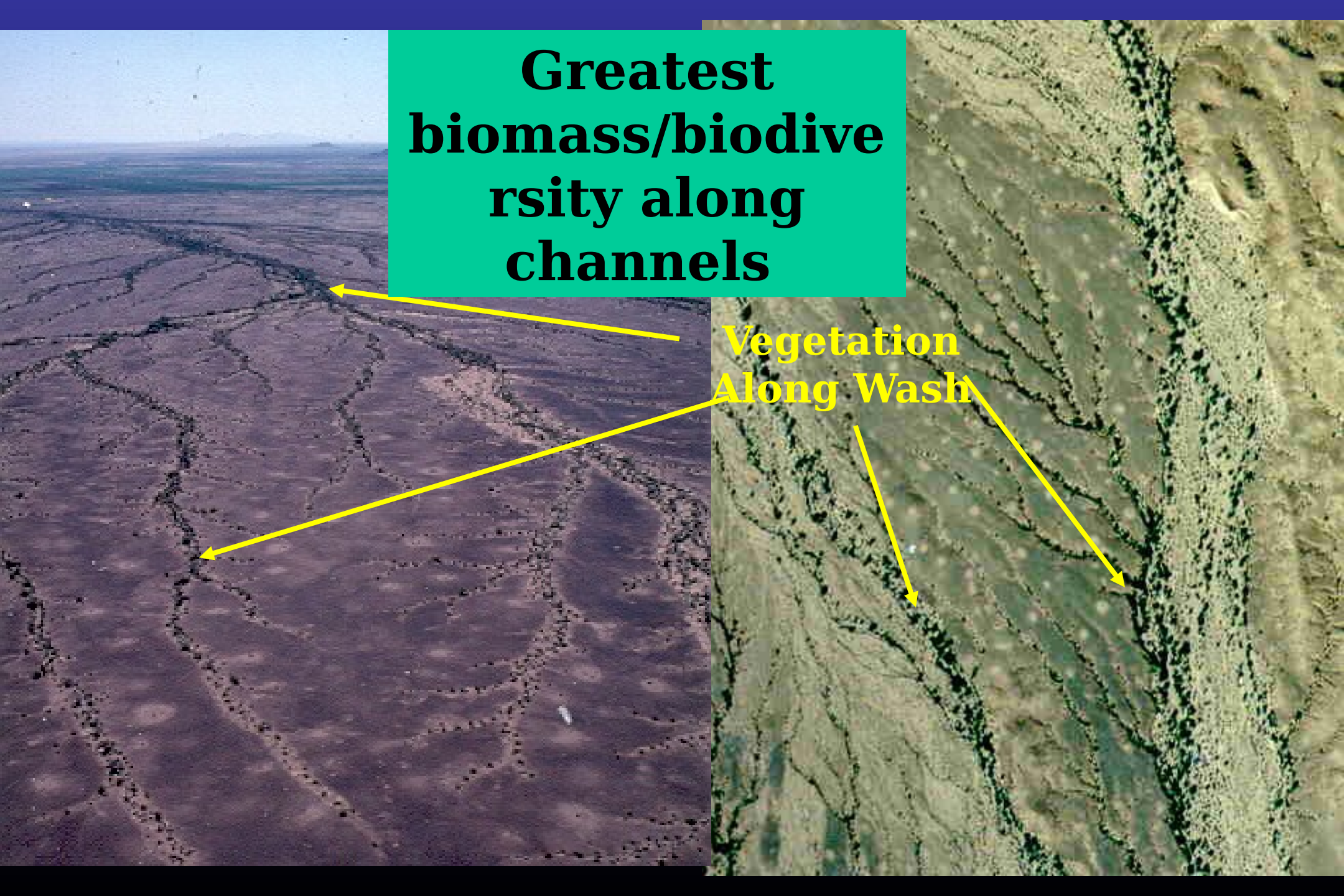
Physical Setting

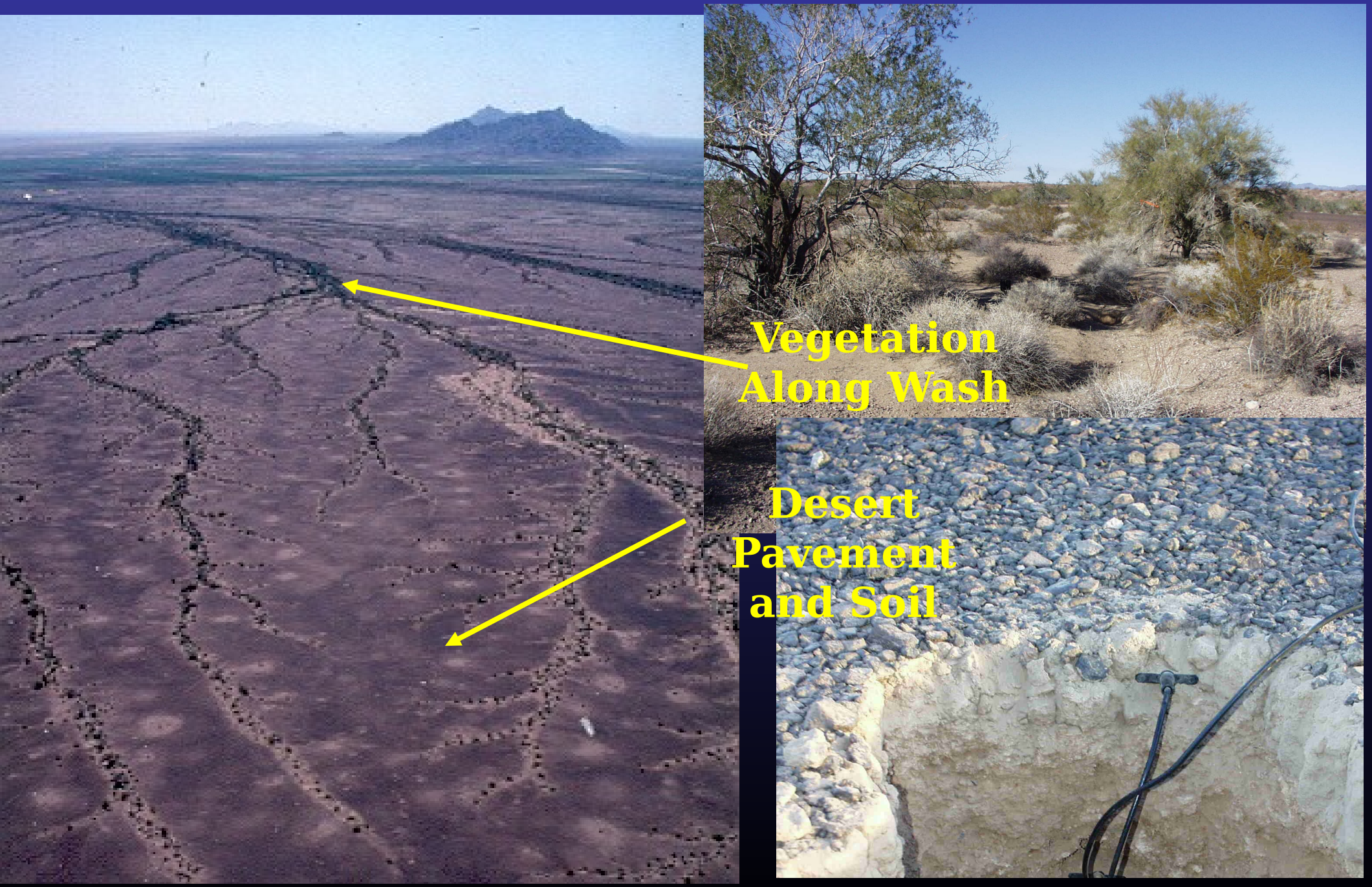
Yuma Proving Ground



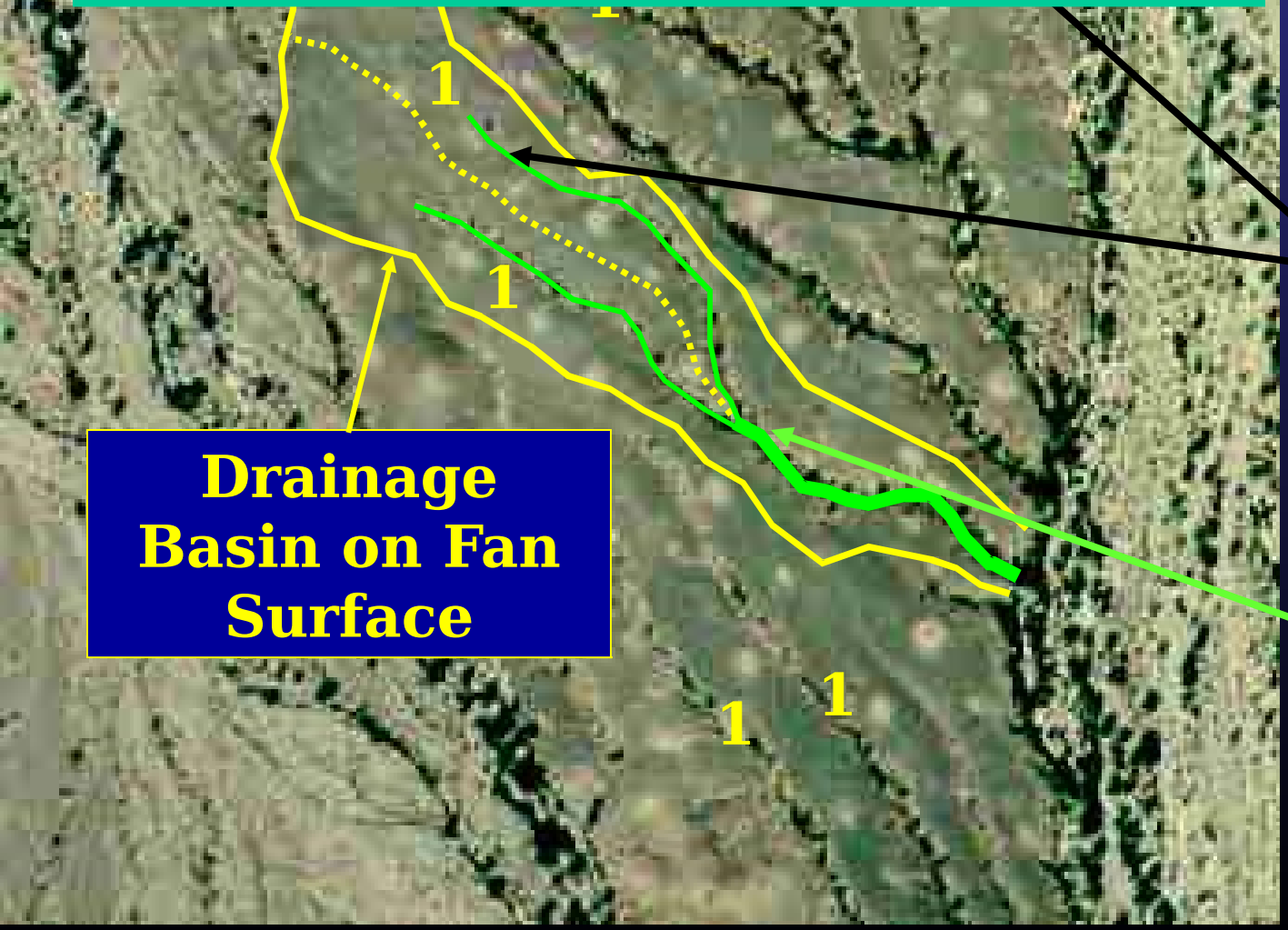
Average rainfall too low to directly support shrubs and trees on most soils




Greatest biomass/biodiversity along channels
Vegetation Along Wash


Vegetation
Along Wash
Desert
Pavement
and Soil

Role of 1st order channels and soil runoff for augmentation of plant available water

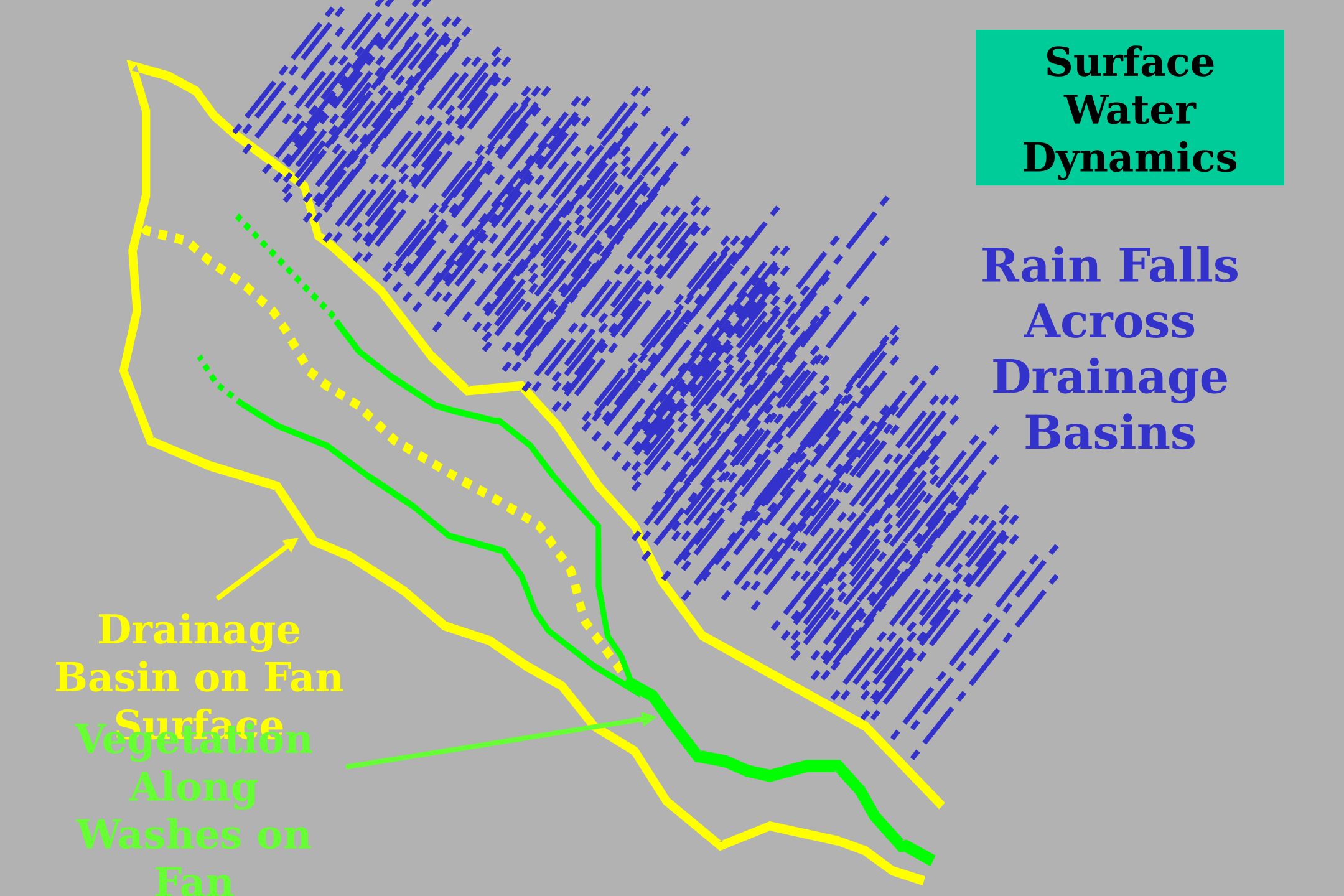


Drainage Basin on Fan Surface

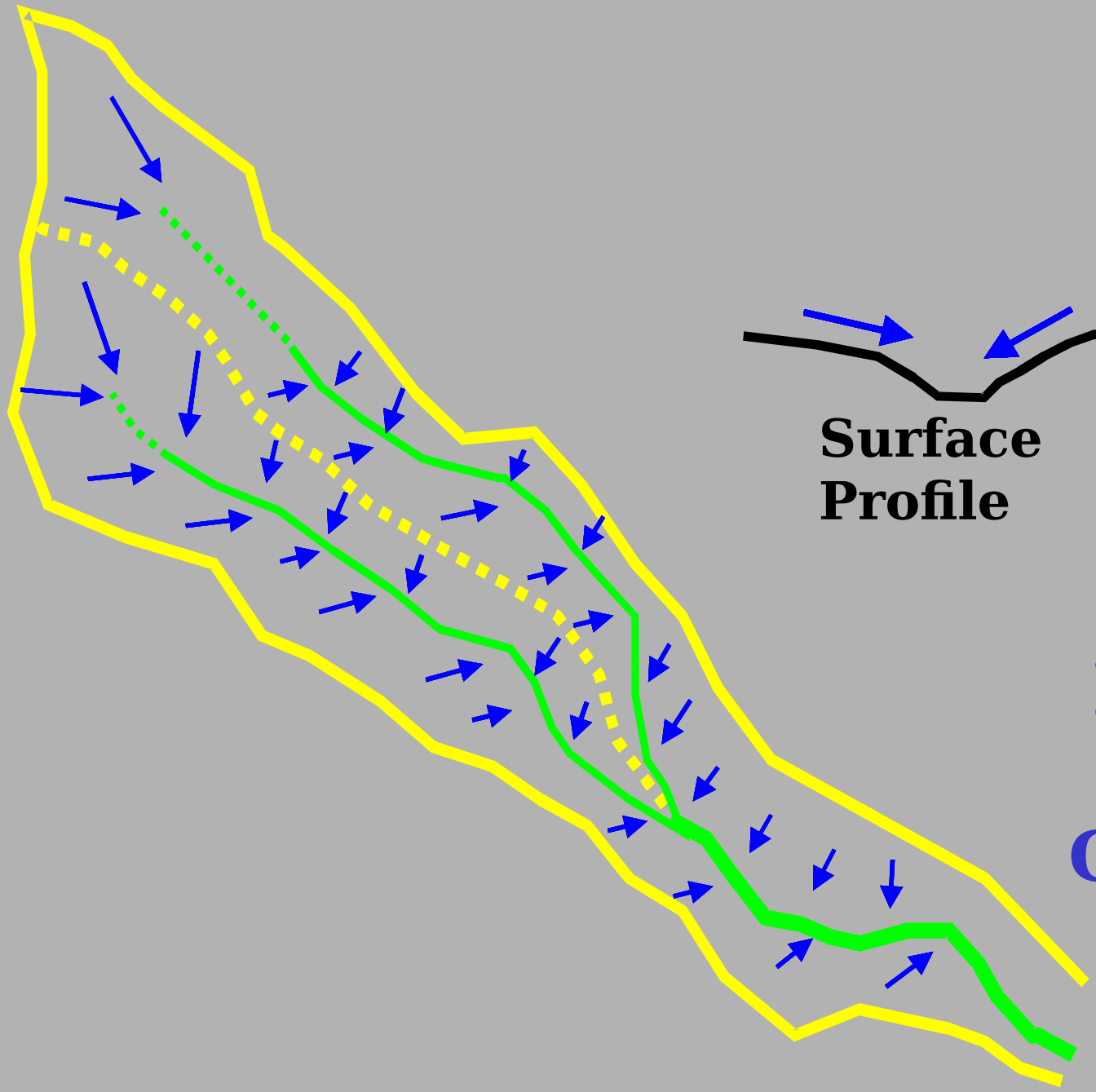
1st Order Channels:

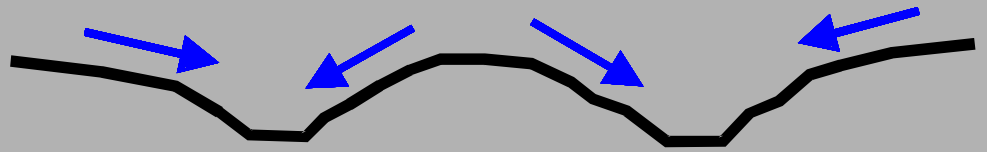
A channel with no tributaries

Vegetation Along Washes on Fan


Surface Water Dynamics
Rain Falls Across Drainage Basins
Drainage Basin on Fan Surface
Vegetation Along Washes on Fan

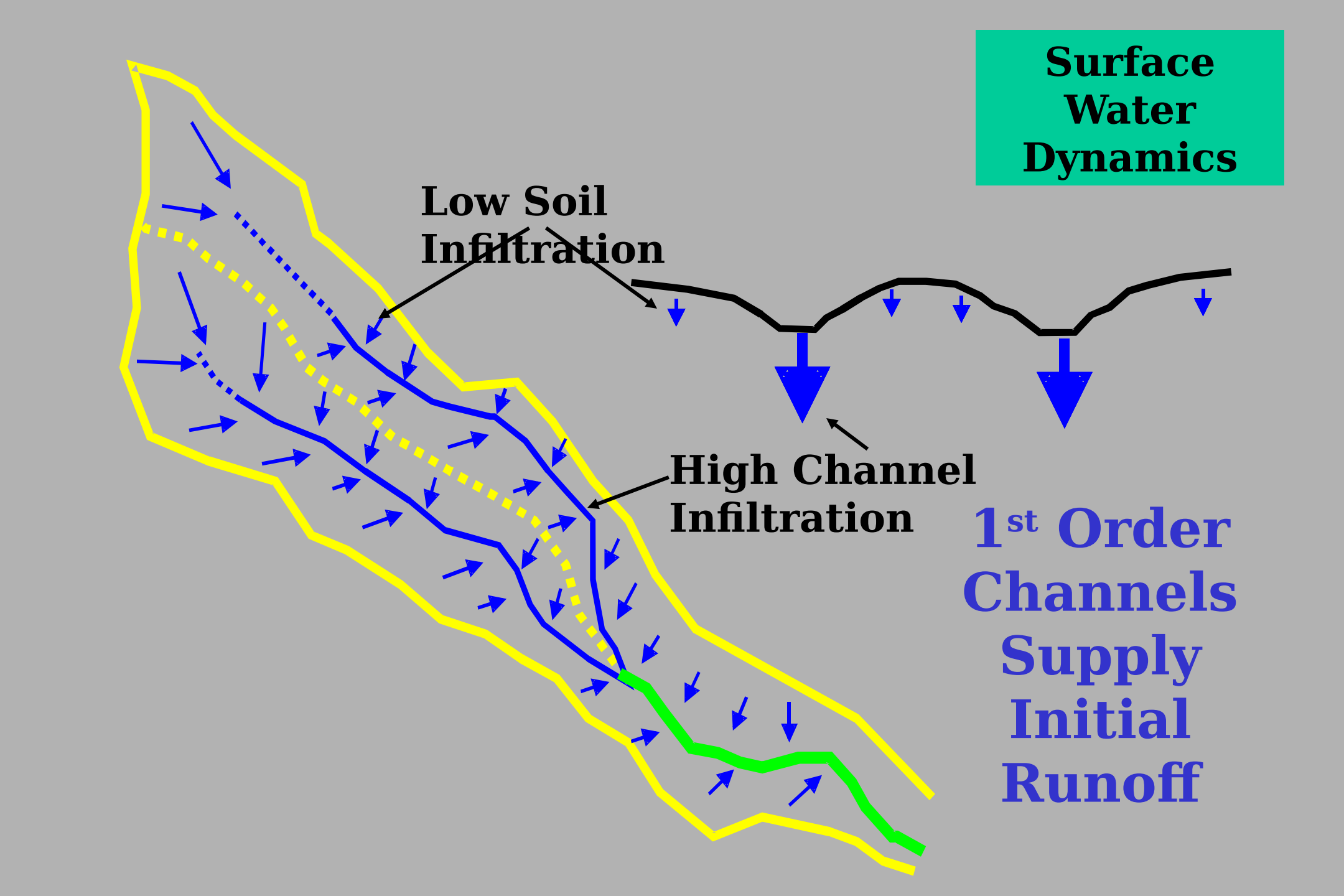
Surface Water Dynamics



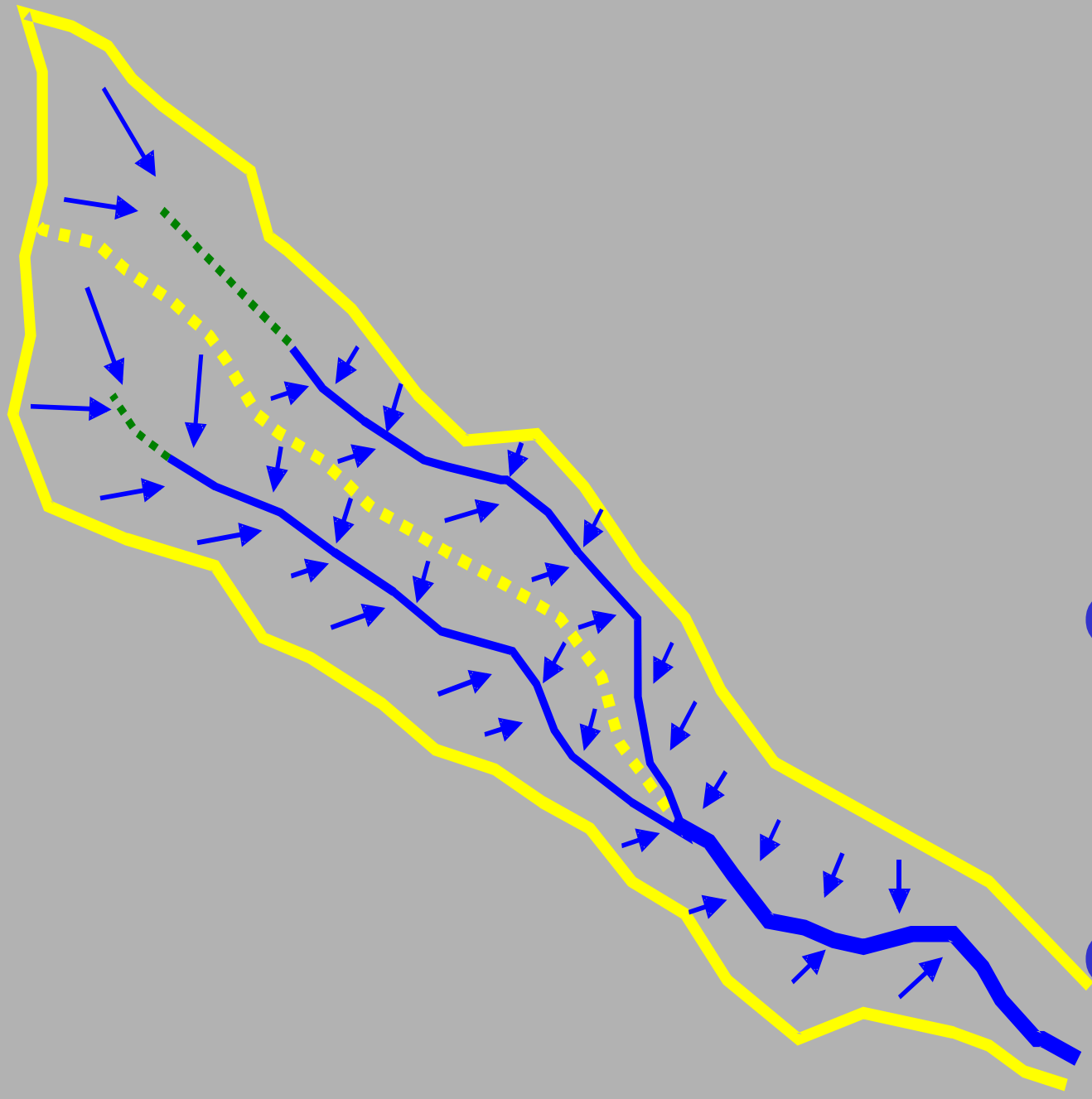


Surface Profile

High Intensity Run Generates Runoff


Surface Water Dynamics
Low Soil Infiltration
High Channel Infiltration
1st Order Channels Supply Initial Runoff

Surface Water Dynamics

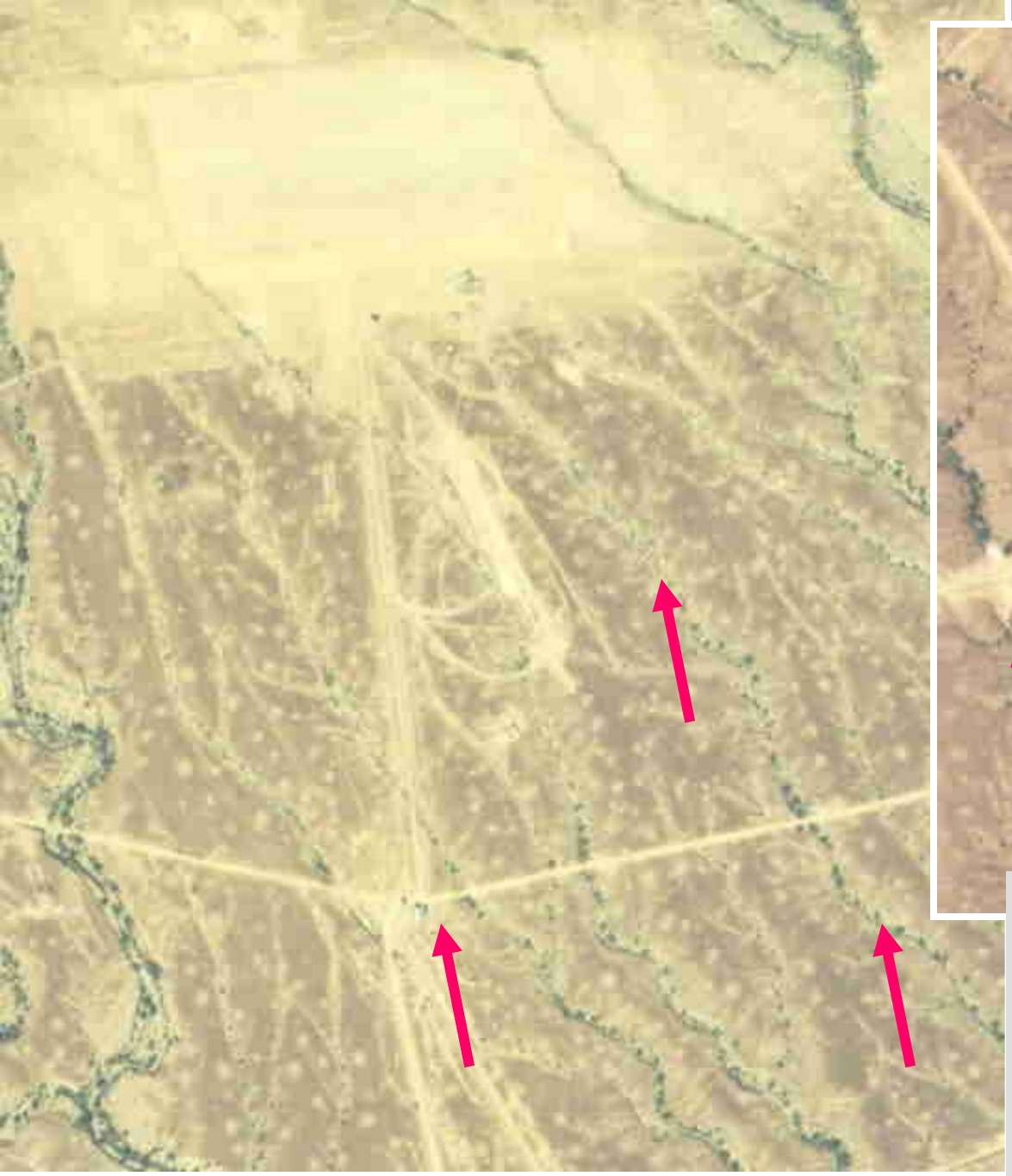


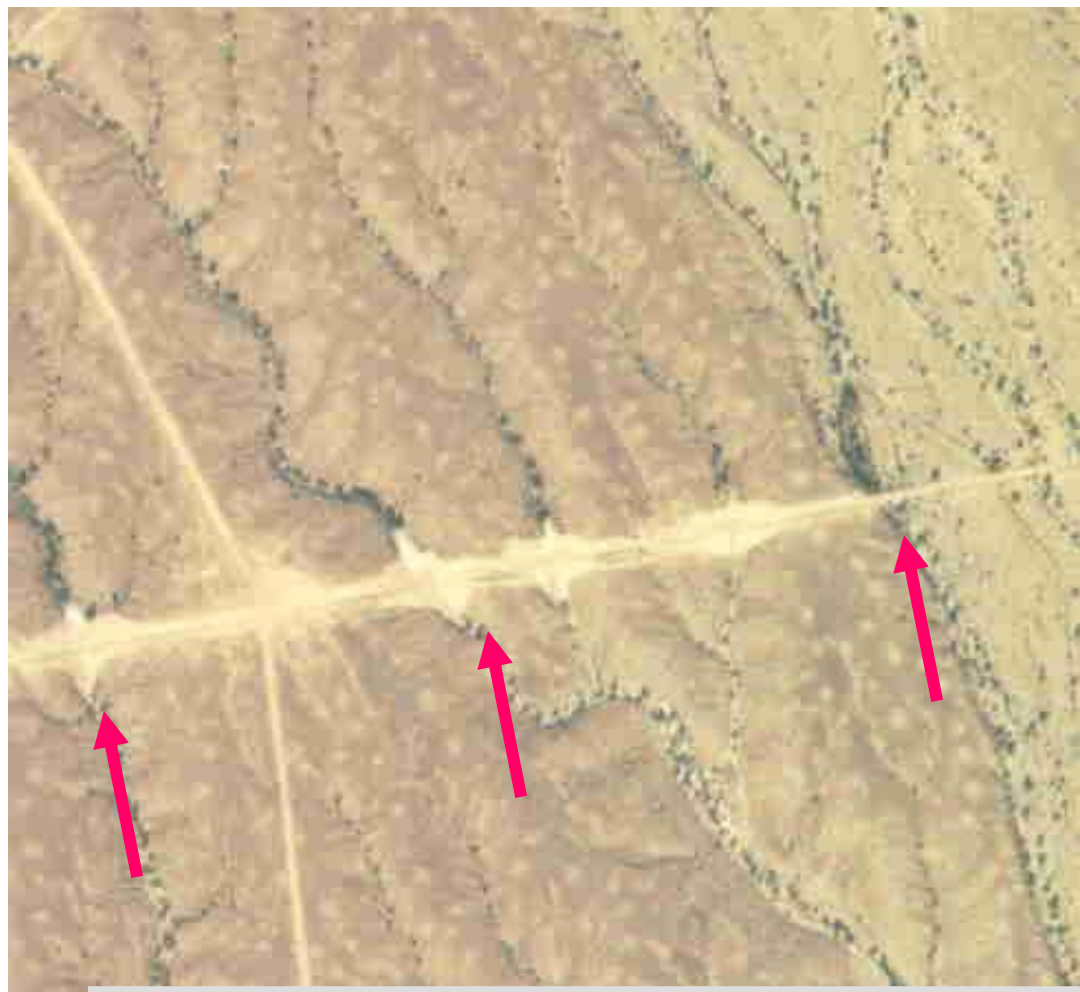
1st Order Channels Supply Higher Order Channels

The Problem

- Disruption of the soil surface and/or blocking of low order drainages will decrease water resources

Widespread disruption of the soil surface from





Reduction in Vegetation/Biomass from Alteration of Surface Water

Roads disrupt flow of water to vegetation

Upstream: Abundant trees/shrubs

Downstream: Impacted trees/shrubs

The Problem

- Disruption of the soil surface and/or blocking of low order drainages will decrease water resources
- **Evidence for recent (historic ?) decline in vegetation**

LCTA Data suggests a decrease in key shrubs: *A. Dumosa* (bursage) and *L. Tridentata* (creosotebush)

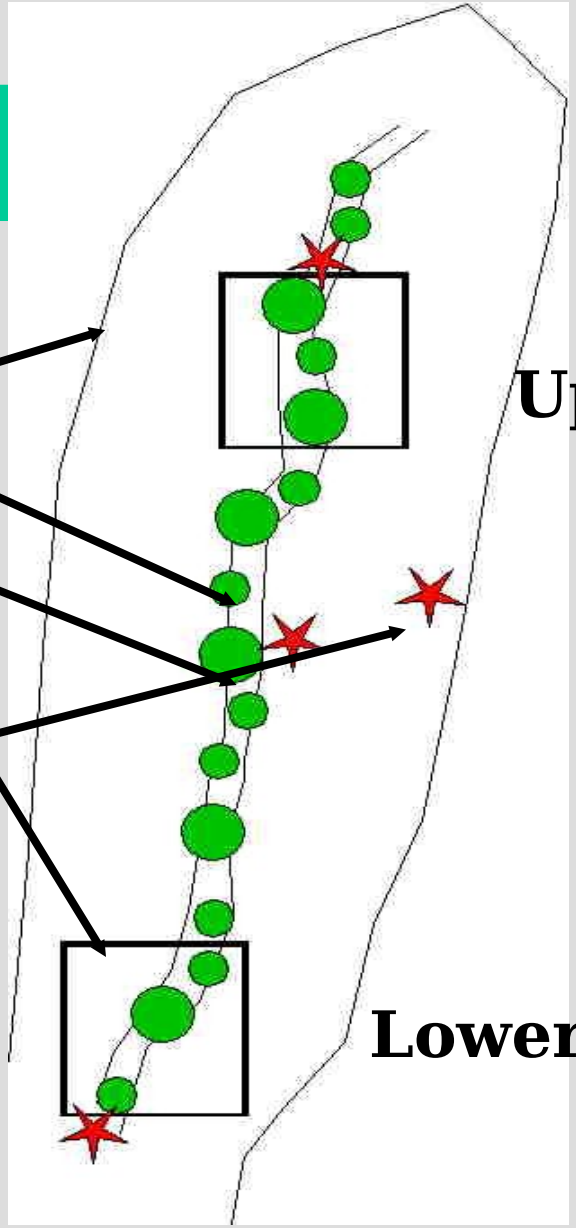
Why? Natural or Human Induced????

Abundant Plant Scars Indicate a Reduction in Vegetation is

Pilot Project at YPG: Premise

- Most water supplied by soil runoff into 1st order channels
- Change is vegetation along 1st order channels indicates change in water supply
- Condition of 1st order channels provides an indicator of ecosystem status (esp. larger ecosystems downstream)

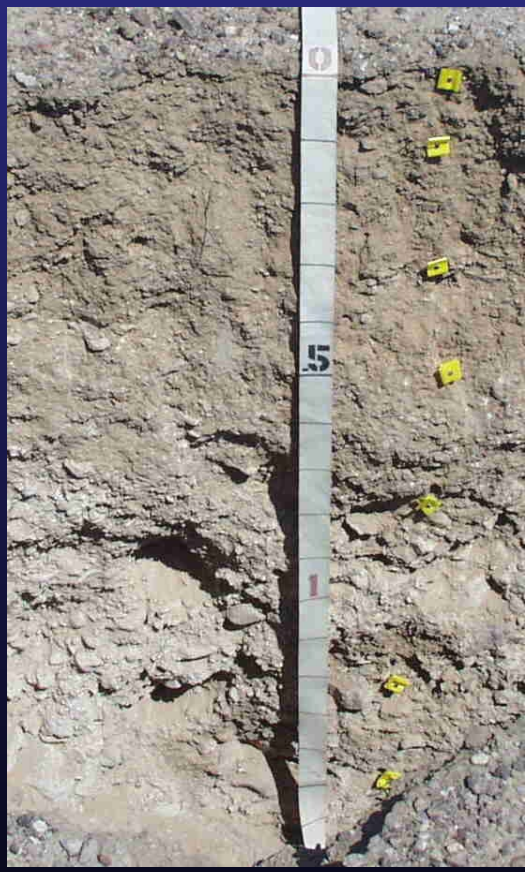
Basic Experimental Layout



Vegetation monitoring: six drainages

Soil moisture monitoring: two drainages

Pilot Project Approach

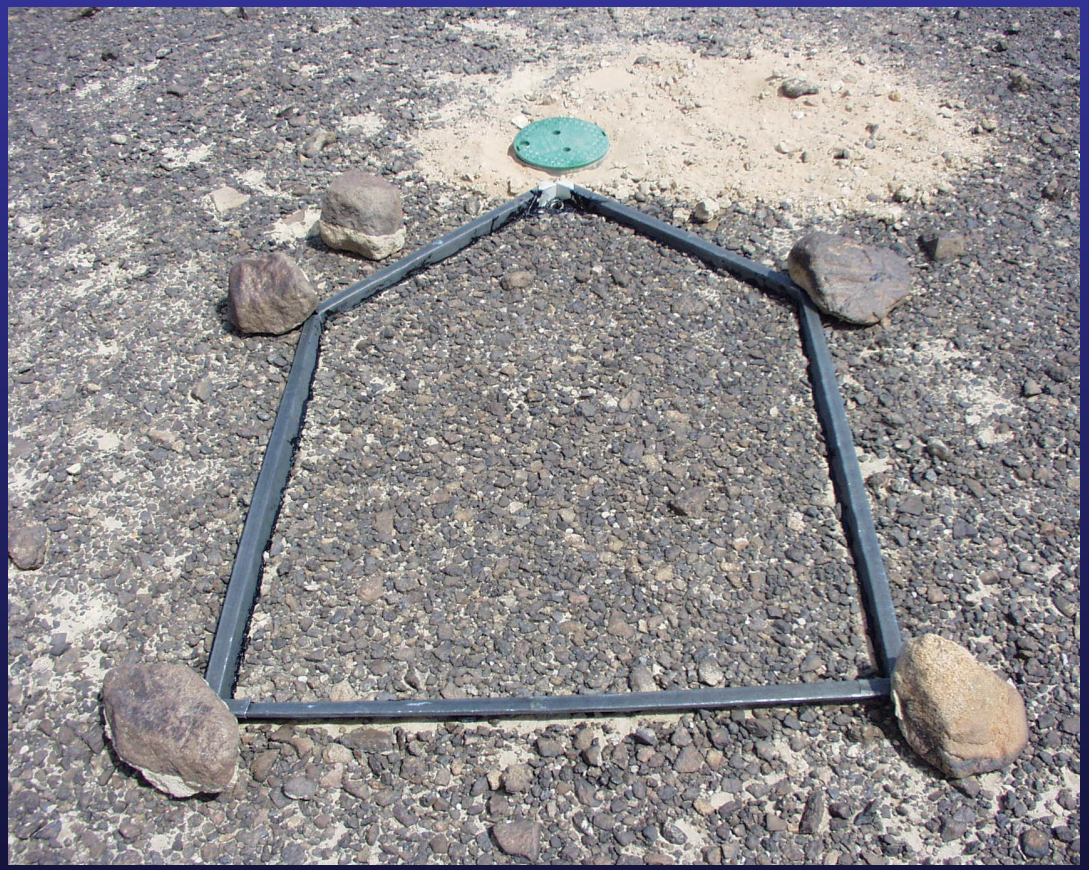


Soil Characterization

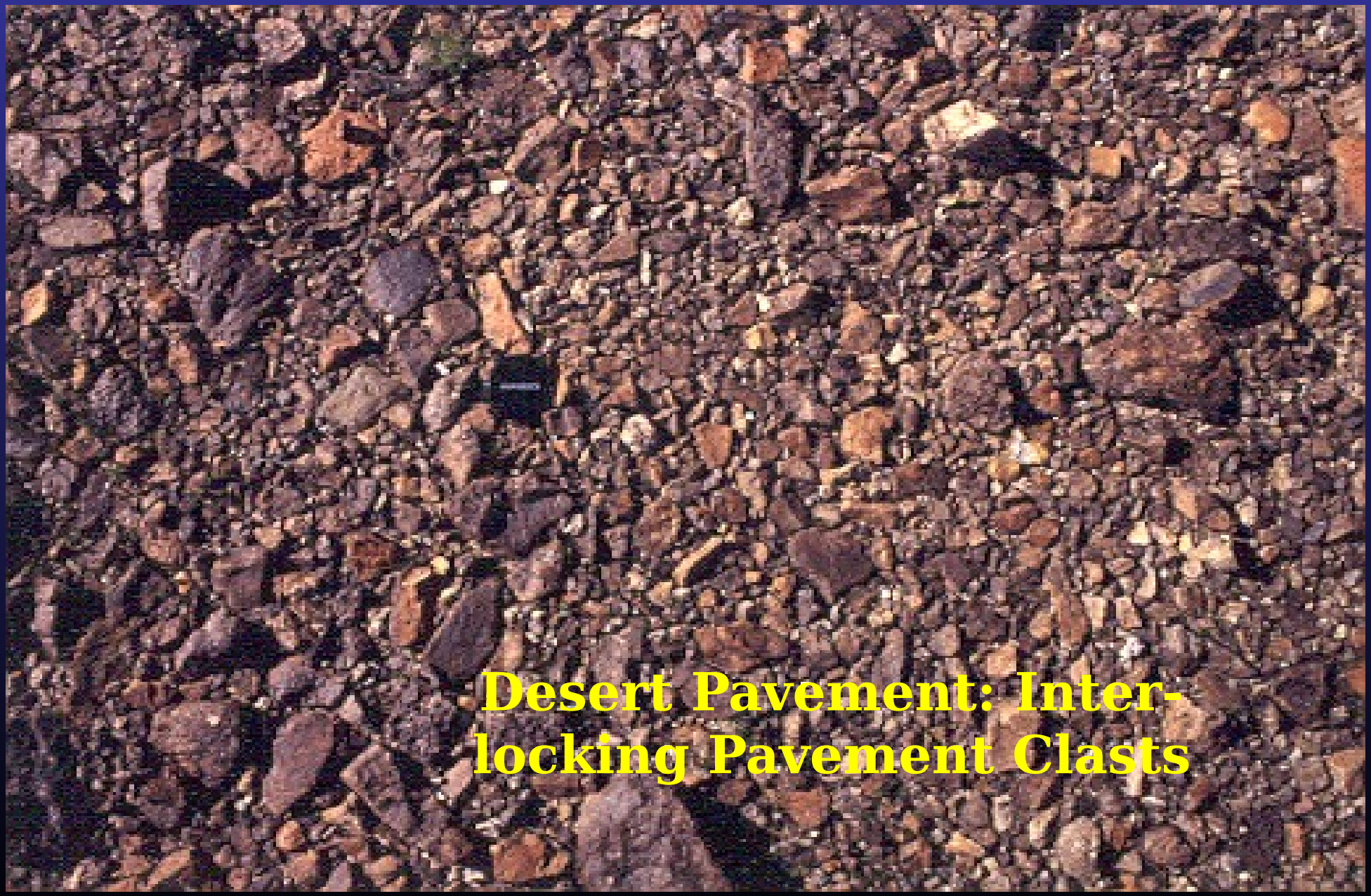
Pilot Project Approach

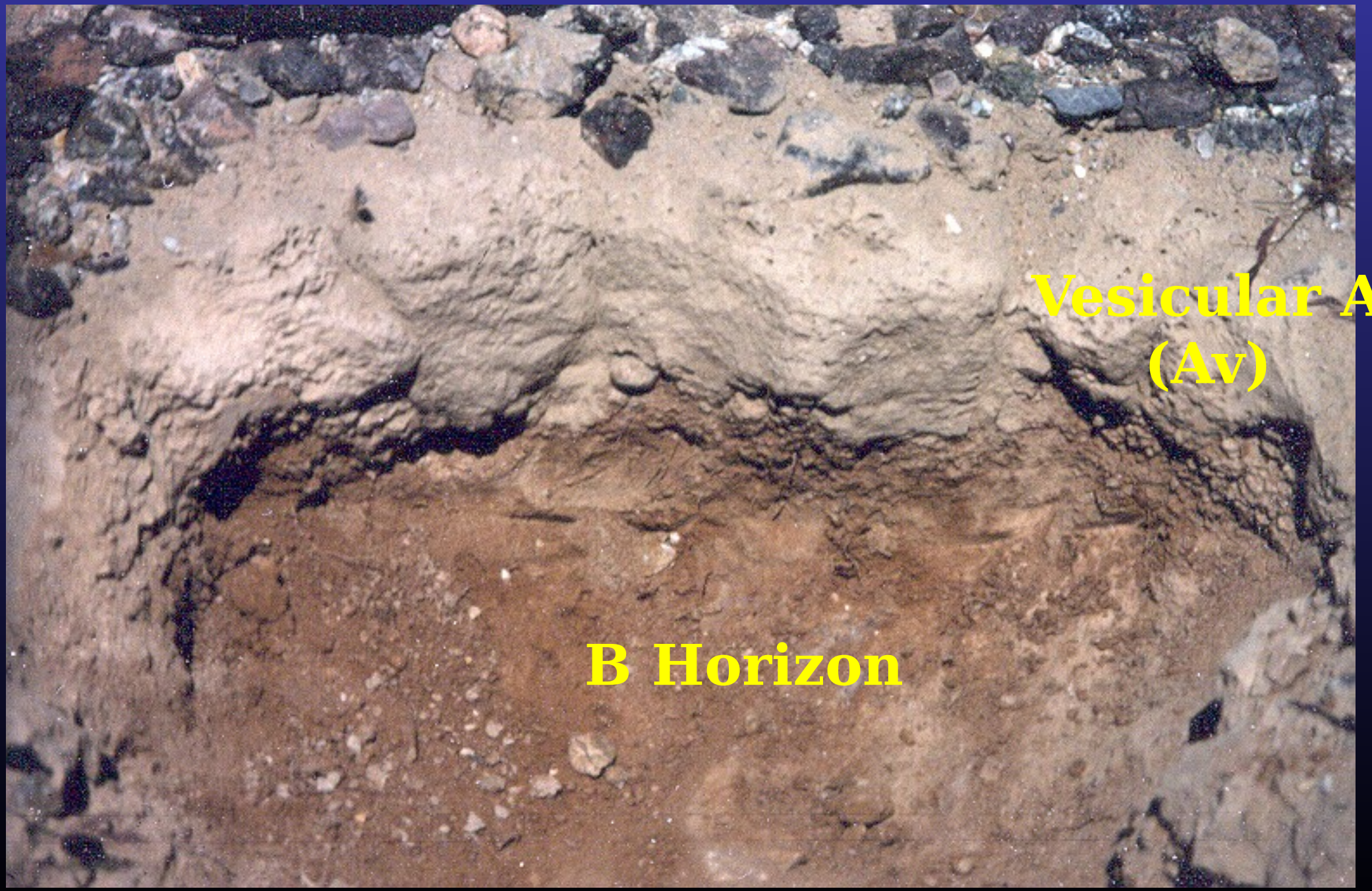
Monitoring Soil Moisture

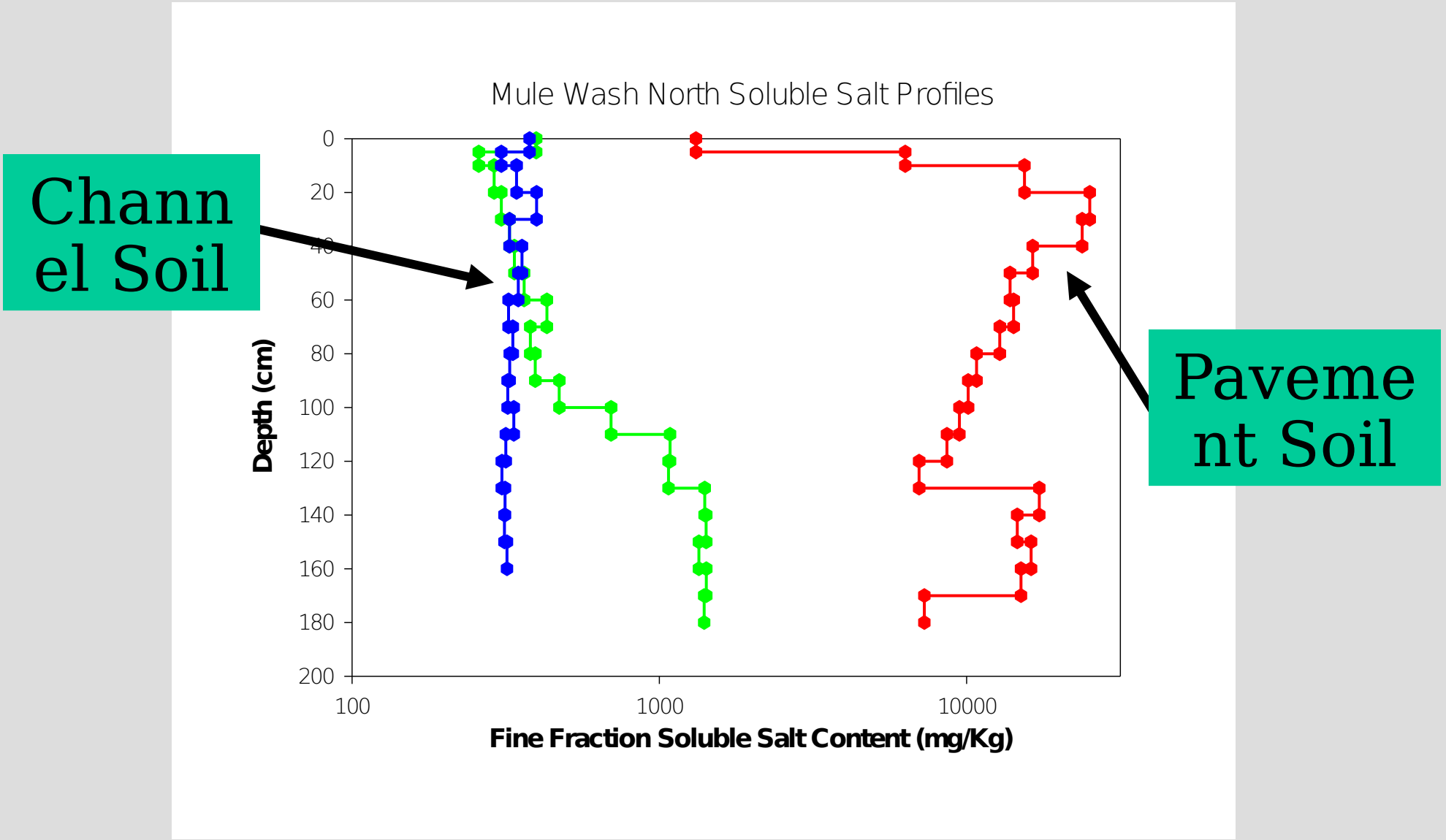
Pilot Project Approach

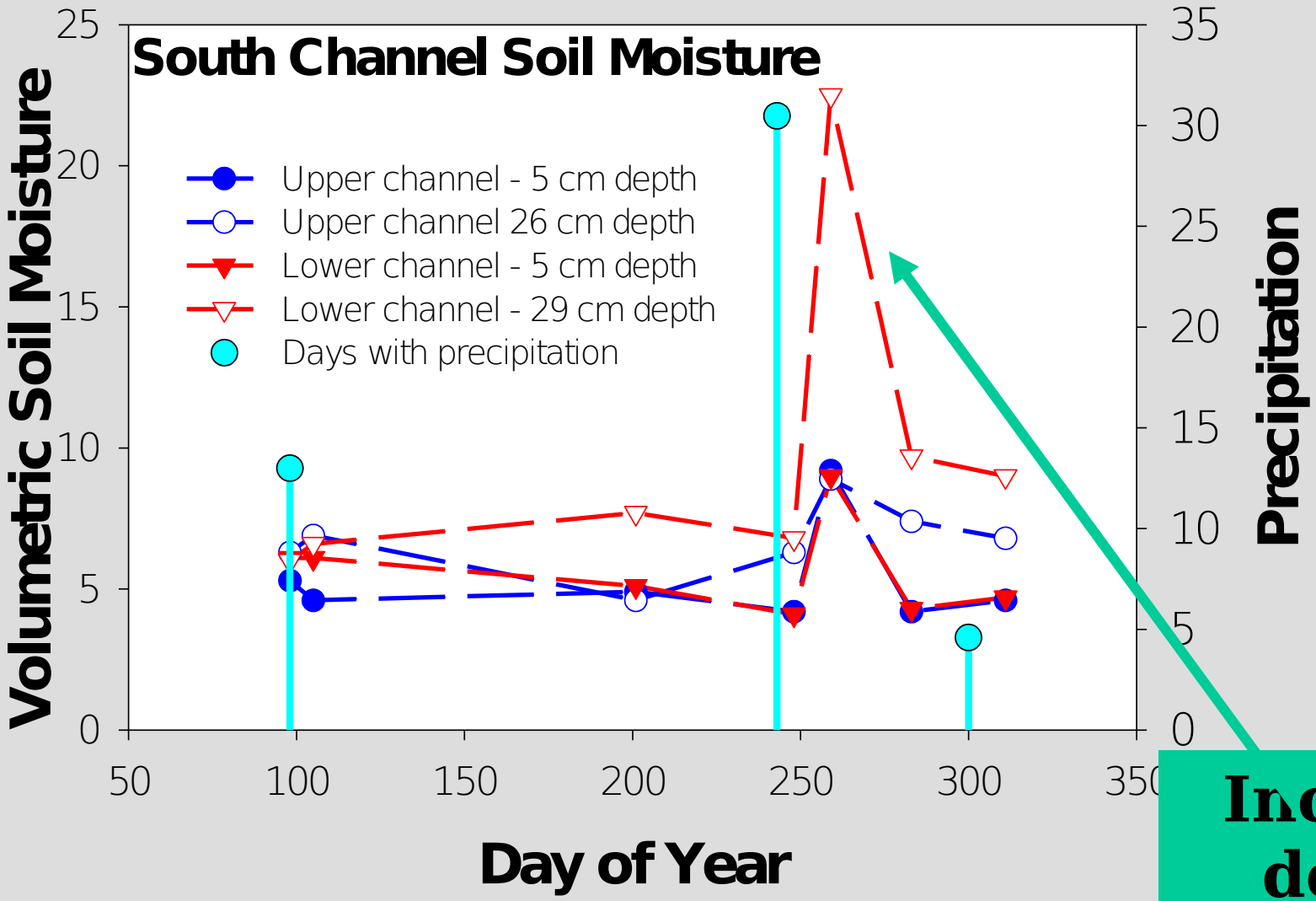


Monitoring Surface Water Runoff

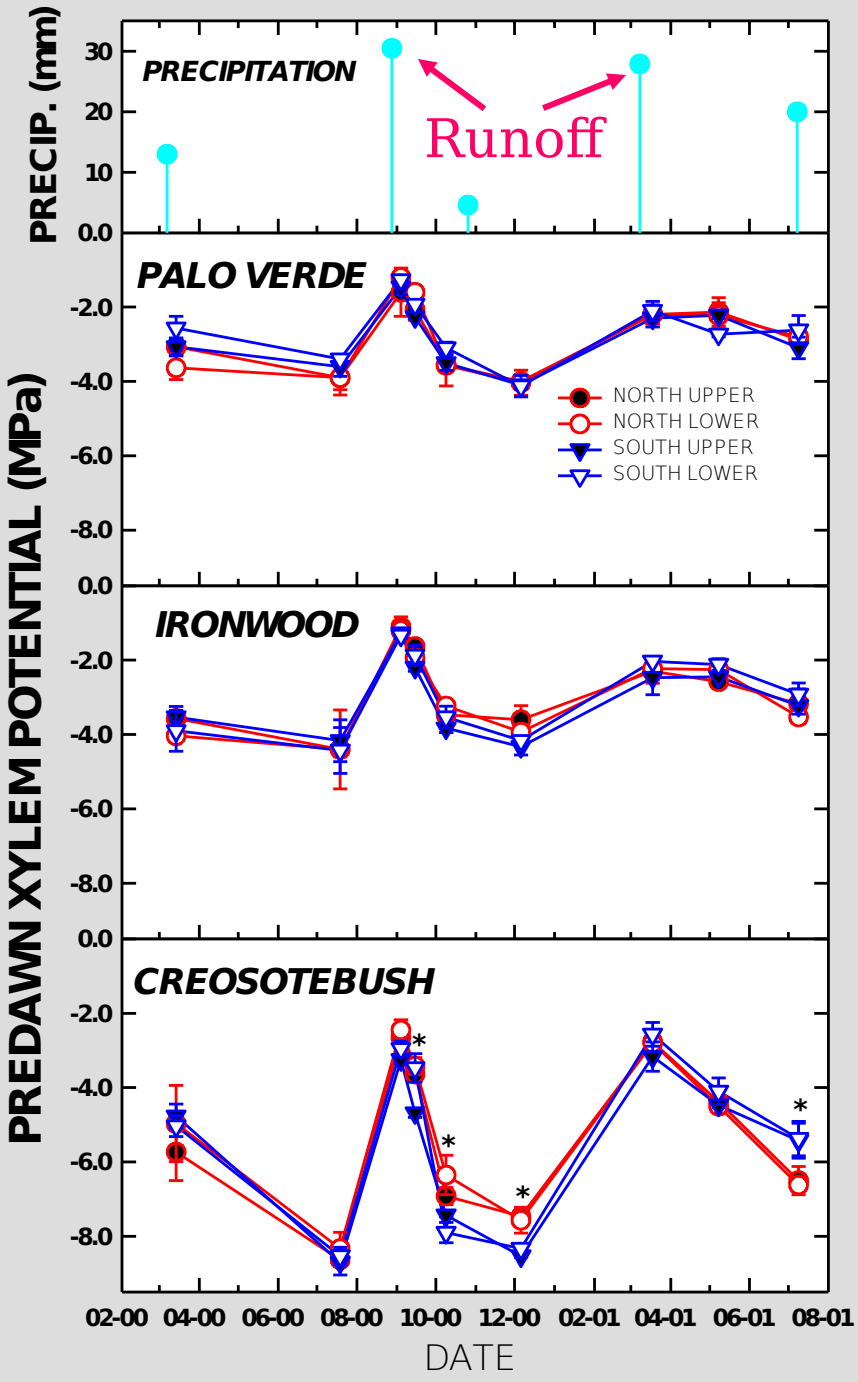

Desert Pavement: Inter-
locking Pavement Clasts


Vesicular A
(Av)
B Horizon


Mule Wash North Soluble Salt Profiles
Channel Soil
Pavement Soil
Depth (cm)
0
20
40
60
80
100
120
140
160
180
200
100
1000
10000
Fine Fraction Soluble Salt Content (mg/Kg)



Increase in deep soil moisture following runoff event



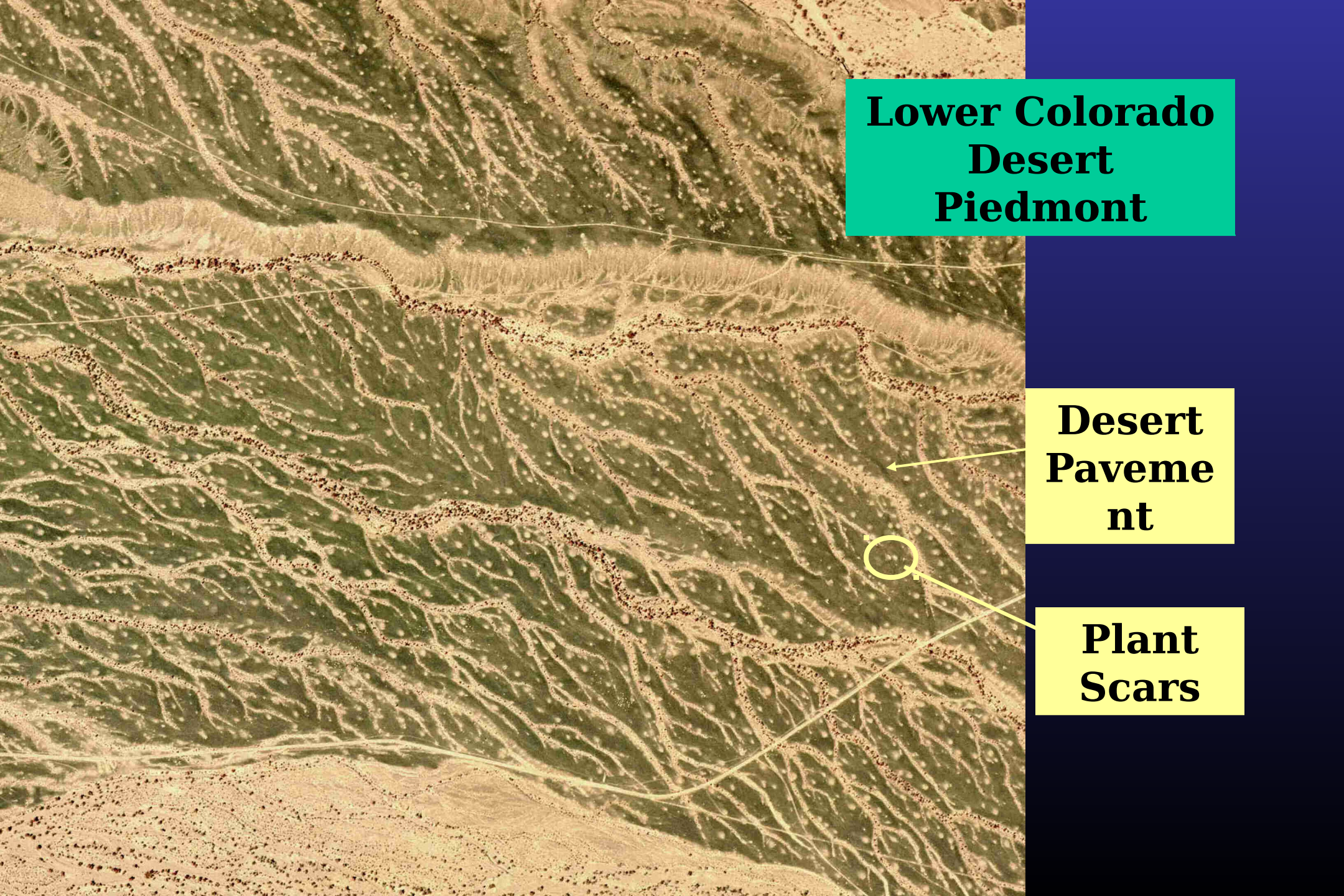
Measuring Plant Water Potential

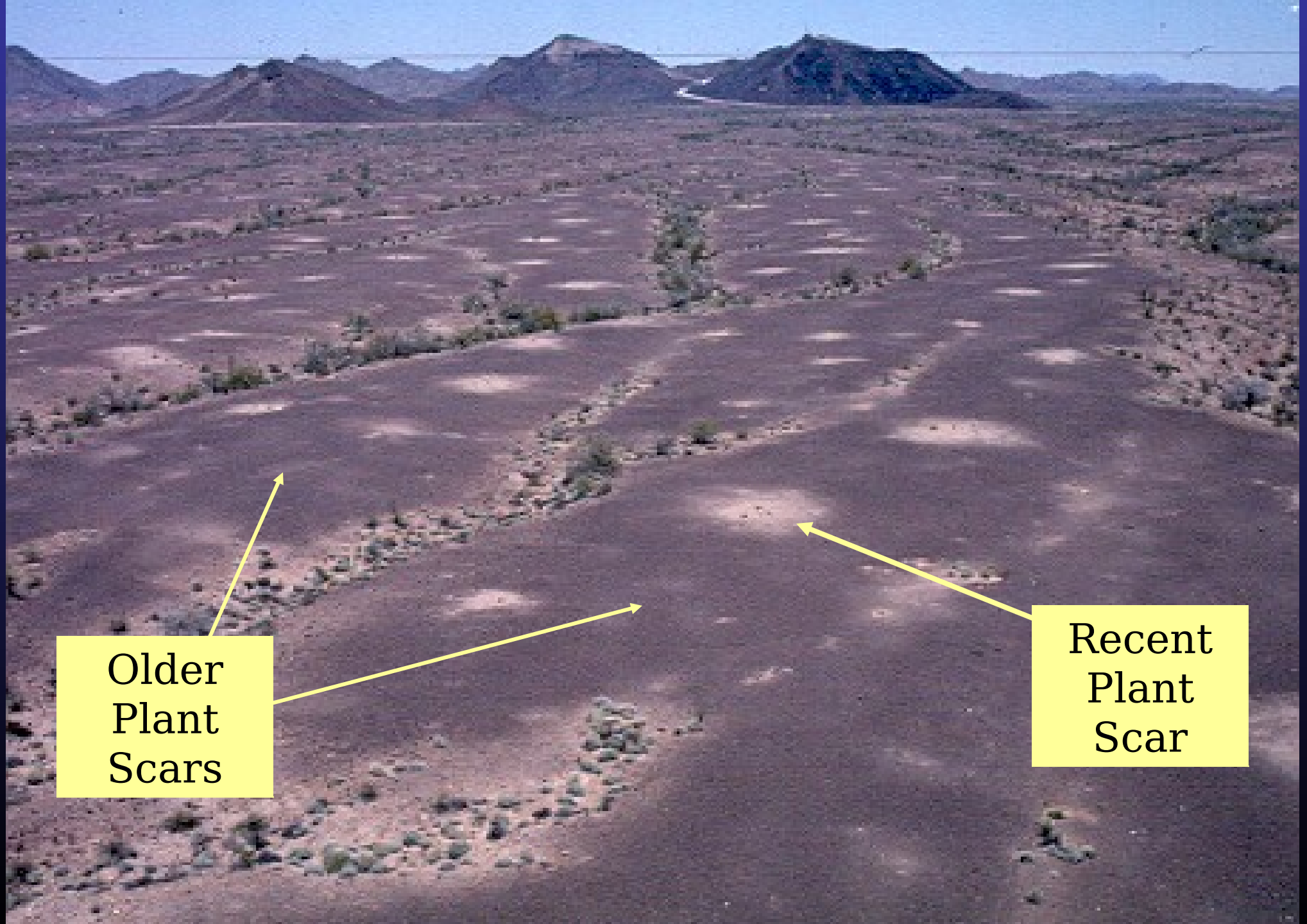
Observations:

- Water potentials for palo verde and ironwood indicate deep (>1.5 m) soil water
- Creosote responds to shallow (<1.5m) soil water

Pilot Project: Results

- Results indicate that the most *critical source* of surface runoff is infrequent large storms (~6 to 18 months/storm)
- Integrity of soil surface critical for runoff
- Soil moisture in upper 1 m cannot account for tree activity
- Trees accessing locally stored soil water, probably 2-5 m deep (vadose zone, NOT groundwater)

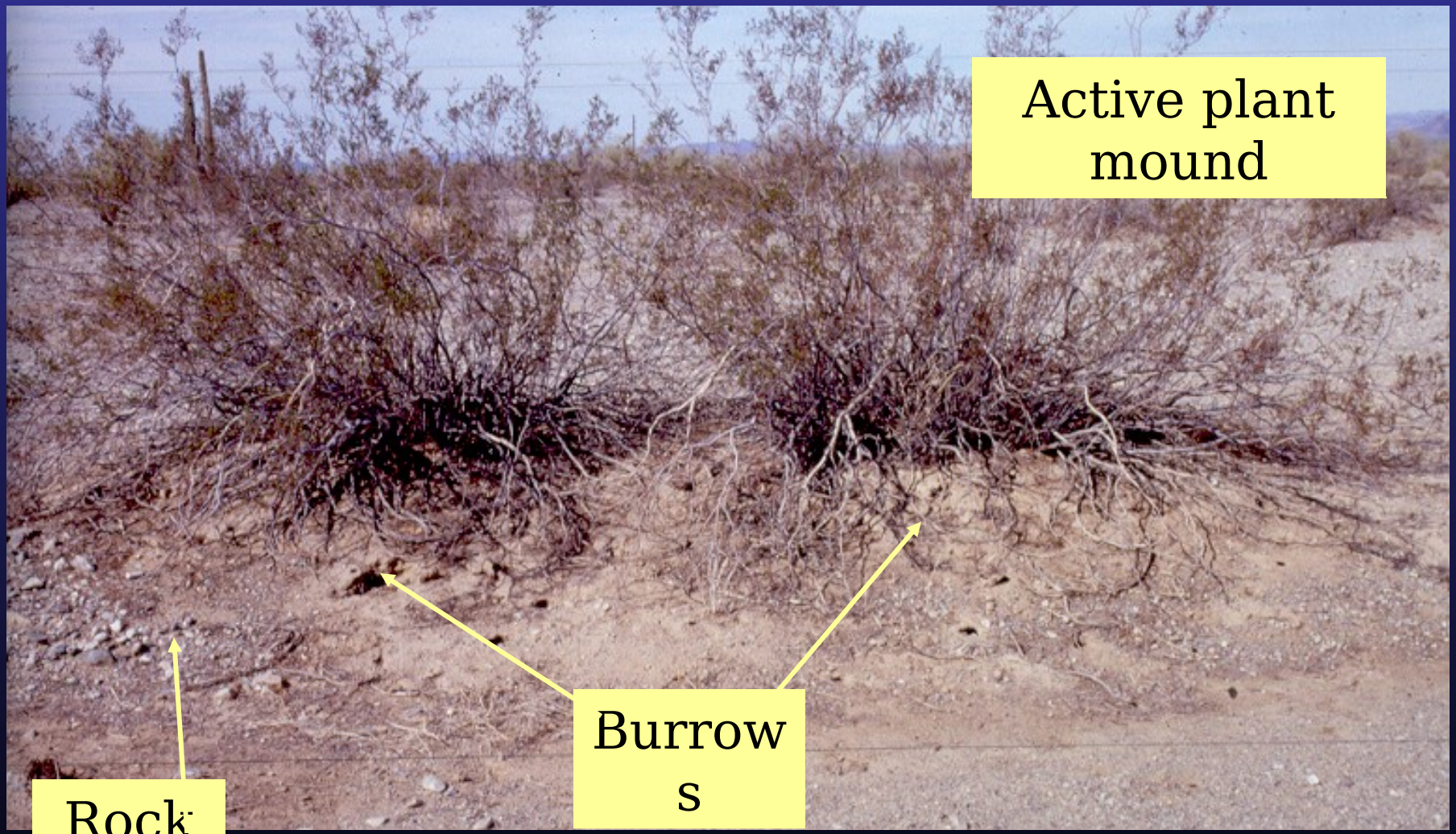

Lower Colorado Desert Piedmont
Desert Pavement
Plant Scars

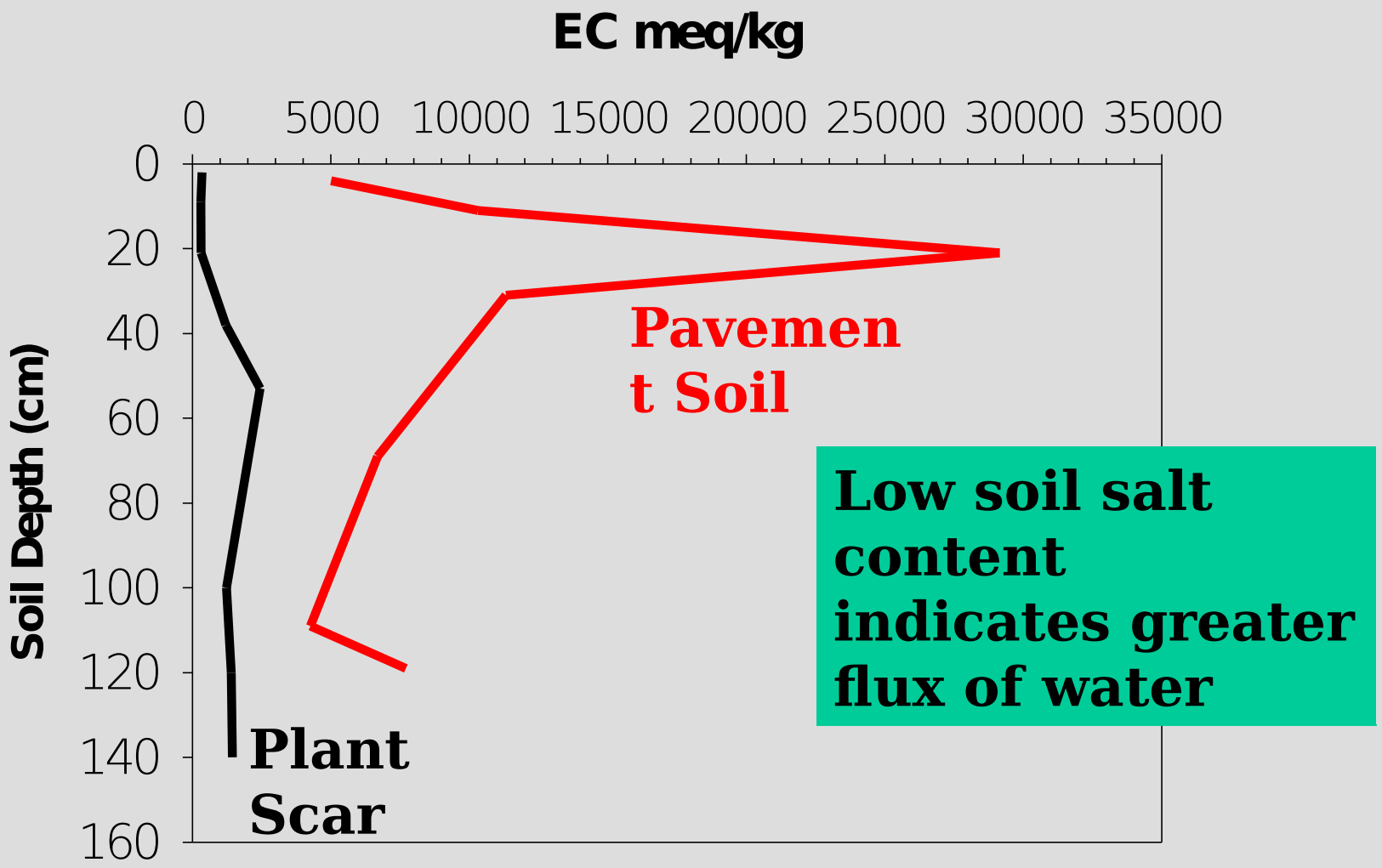

Older
Plant
Scars
Recent
Plant
Scar

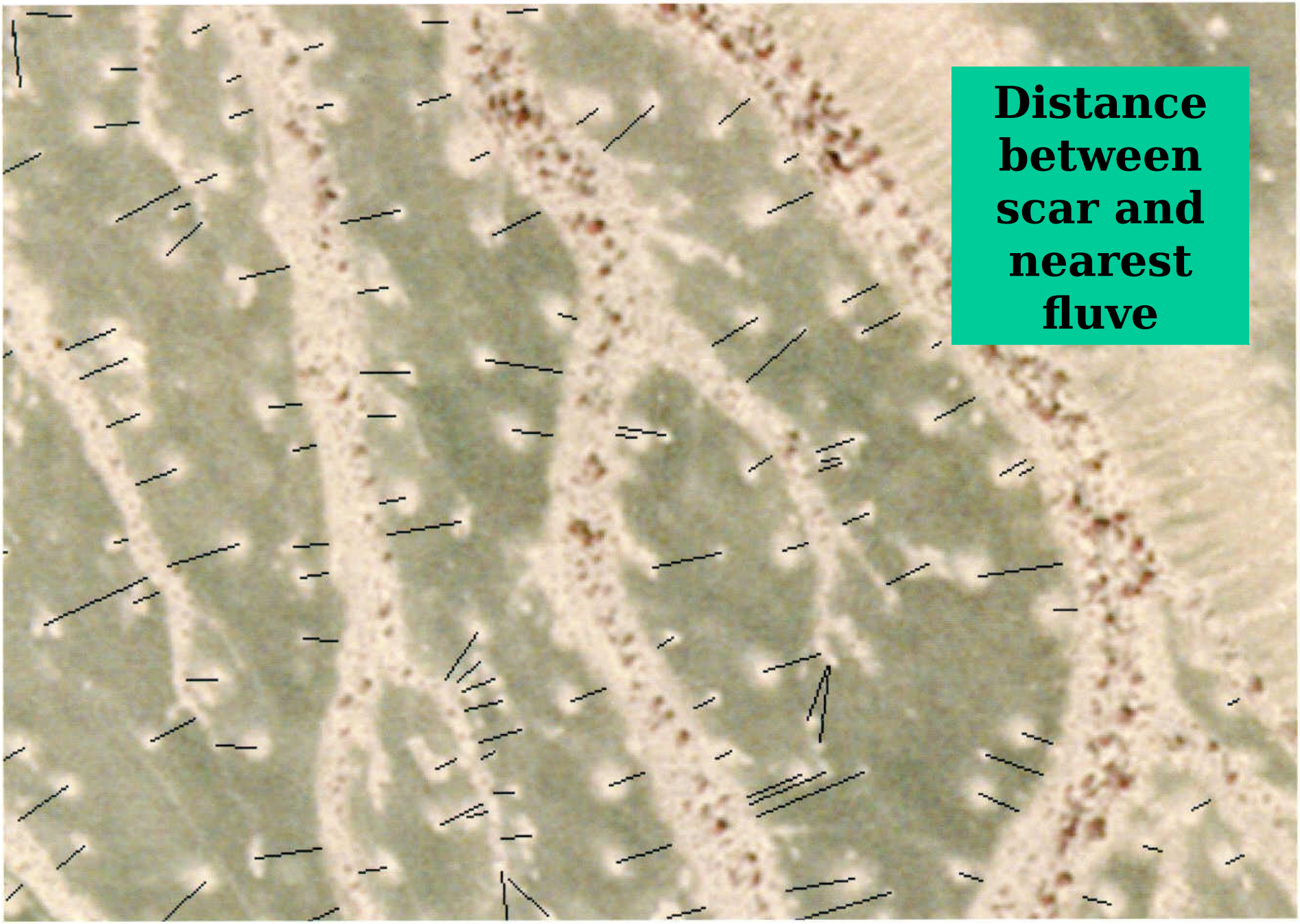
Young plant scar with no pavement

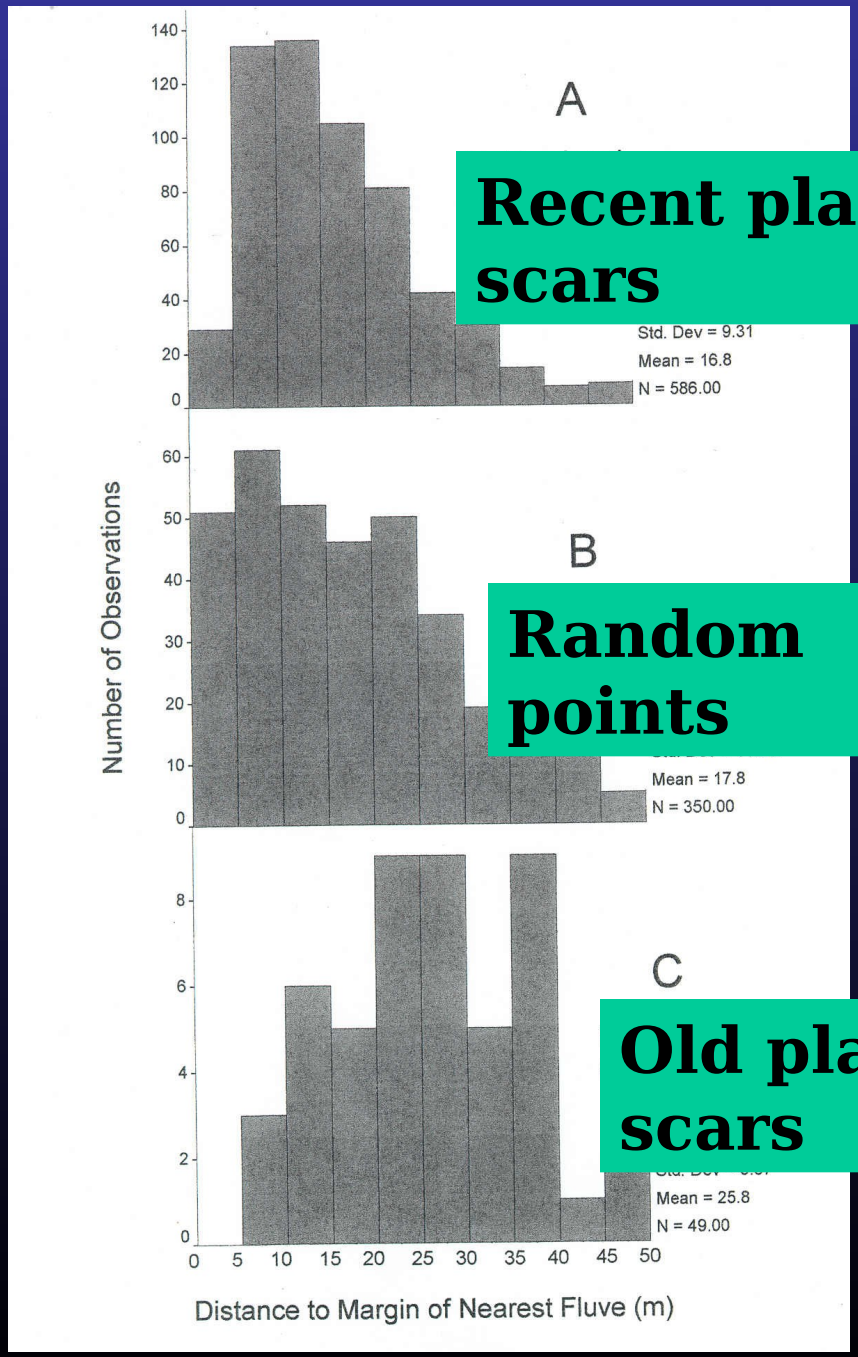
Intermediate age plant scar with partial pavement

Old plant scar with


Active plant mound
Burrows
Rock rim


EC meq/kg
0
5000
10000
15000
20000
25000
30000
35000
Soil Depth (cm)
0
20
40
60
80
100
120
140
160
Pavement Soil
Plant Scar
Low soil salt content indicates greater flux of water


Distance between scar and nearest fluve



Recent plant scars

Random points

Old plant scars

Distribution implies that plant mortality first occurred along central parts of interfluves and has proceeded outward

Results: Formation of Plant Scars

- Once ‘islands’ of flora/fauna activity
- Non-random distribution suggest progressive mortality
  - Mortality may be linked to water availability
- Mechanism for mortality will provide clues about short- and long-term impact of natural and military

Land Management Concerns

- Initial results indicate that *critical source* of plant water is surface runoff from infrequent large storms
- Integrity of soil surface critical for runoff
- Decrease in runoff (i.e., soil degradation from military activities and/or decrease in frequency of large storms will result in a reduction in biomass and

Recommendations

- Monitoring vegetation along first-order channels (and higher?) can serve as an indicator of ecosystem status

- Evaluation of soil water/surface hydrology critical for monitoring ecosystem health
- Knowledge of soil and geomorphic control on the flux of soil water can be used to enhance management strategies

Continuing Project Questions:

- How does the system respond to different storm events—frontal, convective, and tropical?
- How can the available monitoring techniques be used to generate a measure of ecosystem health?
- What is the contribution of the military in affecting ecosystem change?
- Approach for use at installations in other dryland areas needs to be evaluated